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Determination of Some Physical Properties of Biodiesel Extracted from Garlic Oil

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Abstract

The depletion of fossil fuels together with its negative environmental effects raised question on it`s over dependent. One of the alternative solutions toward this problem is the use of biodiesel which can be produced through the process of transesterification. The physical properties of biodiesel (pour point, flash point and fire point) extracted from transesterified garlic oil was investigated. The crude garlic oil was purified , transesterified and subjected to Fourier Transform Infrared (FTIR) analysis in order to determine the functional group of the samples. The pour point, flash point and fire point of transesterified garlic oil was found to be 4^0C, 160^0C and 185^0C, respectively, which are within the ASTM standard. The FTIR indicate the presence of ester (biodiesel) on transesterified garlic oil. The research shows that the garlic oil can be used as biodiesel feedstock.

Keywords: *Biodiesel, Garlic Oil, Pour Point, Flash Point, Fire Point.*

1. Introduction

Due to the awareness of adverse effects of conventional fuels to environment and the frequent rise in crude oil's price, the need for renewable sustainable and environment friendly alternative source of energy has attracted more attention in recent years (Ismail *et al.,* 2022). Renewable technologies are considered as clean sources of energy and optimal use of these resources minimize environmental impacts, produce minimum secondary wastes and are sustainable based on current and future economic and social societal needs (Chao-Yi *et al.,* 2014). Sun is the source of all energies. The primary forms of solar energy are heat and light. Sunlight and heat are transformed and absorbed by the environment in a multitude of ways. Some of these transformations result in renewable energy flows such as biomass and wind energy. Renewable energy technologies provide an excellent opportunity for mitigation of greenhouse gas emission and reducing global warming through substituting conventional energy sources (Banwal *et. al.*, 2015).

There are many forms of renewable energy. Most of these renewable energies depend in one way or another on sunlight. Examples are solar, wind energy, hydroelectric energy, biomass, hydrogen and fuel cells, geothermal power and other forms of energy (Azarpour *et al.,* 2013). History records that Rudolph Diesel, the inventor of the engine that bears his name, used vegetable oils as a diesel fuel alternative in his engines as early as 1900. For many years, the ready availability of inexpensive petroleum middle distillate fuels provided little incentive for experimenting with alternative, renewable fuels for diesel engines and heating systems (Peterson, 1986). Rudolf Diesel, in 1912, reported that, "The use of vegetable oils for engine fuels may seem insignificant today. But such oils may become in course of time as important as petroleum and the coal tar products of the present time" (Murugesan *et al.,* 2009). The energy crisis of the 1970s sparked a renewed interest in the use of vegetable oils as fuel and today the subject continues to attract attention because of the successful results obtained in the applications (Karaosmanoglu, 1999; Knothe, 2010). Again the global energy demand, sudden fluctuations of oil prices and environmental concerns due to vehicle exhaust gases are increasing. The most feasible way to solve these problems is to use alternative fuels. Among alternative fuels are biofuels which are defined as liquid or gaseous fuels for the transportation sector that are predominantly produced from biomass (Sundar Raj & Sendilvelan, 2010; Zuhal & Kemal, 2004). Hence, there is need for better alternative sources. Biofuels have received a great deal of attention due to the increase in global energy demands and the necessity of alternative clean fuels and energy (Bateni *et al*., 2016; Samadi *et al.,* 2017; Bateni *et al.,* 2017).

Biodiesel is the name given to fuel for Diesel engines created by the chemical conversion of animal fats or vegetable oils. Pure vegetable oil works well as a fuel for Diesel engines itself, as Rudolf Diesel demonstrated in his engine at the 1900 world's fair with peanut oil as the fuel (Indhumathi *et. al*., 2014). Biodiesel is a petroleum diesel substitute and one of the most promising biofuels due to its environmental compatibility and biodegradability (Bateni and Karimi, 2016; Tremblay and Montpetit, 2017; Bateni *et al.,* 2017). Vegetable oils such as neem oil, jatropha oil, castor oil, sesame oil, garlic oil etc have become more attractive in the recent years owing to its environmental benefits and the fact that it is made from renewable resources (Nigam and Singh 2011). Vegetable oils are renewable and potential source of energy with an energetic content close to diesel fuel. Oils derived from vegetable sources may in course of time become as important as petroleum and the coal tar products of present time. Recent decrease in minerals oil prices and to the fear uncertainties concerning minerals oils availability renewed the interest in vegetable oil fluid for industrial application (Paul, 2007).Garlic, scientifically known as *allium satvium*, is a relative of the onion family and one of most commonly used ingredients across the globe. Caltivated mostly in the tropical region, garlic packs, both, culinary benefits for it distinctly pungent flavor as well as a multitude of health and medicinal benefits. Garlic oil contains volatile sulphur compound such as diallyl disulfide which constitute 60% of the oil. Steam distill garlic oil typically has a pungent and disagreeable odor and brownies yellow in color (Satyal *et al.,* 2017).

The measurement of the physical properties of biodiesel extracted from transesterified garlic oil has not been reported in the literature. Therefore, the aim of this paper is to determine the physical properties of biodiesel extracted from transesterified garlic oil.

2. Material and Methods

2.1 Chemicals

The materials and reagents used in carrying out this research are as follows: crude garlic oil (Linnaeus), 8% sodium hydroxide (NaOH), 64 % citric acid ($C_6H_8O_7$, purity: 99.7%), Silicon reagent, activated carbon, acetone, and distilled water (H_2O).

2.2 Equipment

The equipment used in carrying out this study are magnetic stirrer with thermostatically controlled rotary hot plate (IKA C-MAG HS10), Brook field {Brook field, RVDV-I}, thermometer, measuring cylinder, Digital weight balance (AND model GT2000 EC), beaker, 24 cm filter paper, funnel, Digital stopwatch, sampling bottles, spatula.

2.3 Methodology
The methodologies employed during this research are sample purification, transesterification and sample measurement.

2.3.1 Sample Purification
200 ml of the Garlic oil has been measured using measuring cylinder and preheated to $70^0\ C$ using hot magnet stirrer with thermometer. Similarly, 1.5 ml citric acid was added to the heated oil sample and continuously heated and stirred for 15 minutes at $70^0 C$. Furthermore, 4 ml of 8% NaOH (by dissolving 8g NaOH in 100 ml of distilled water) was also added to the oil and continuously heated and stirred for 15 minutes at $70^0\ C$.The mixture is then transferred to the vacuum oven where it has been heated at $85^0\ C$ for 30 minutes. Then taken back to the hot magnetic stirrer and heated at $70^0\ C$ after which a 2g of silicon reagent is added while it was being heated and stirred for 30 minutes. Then the temperature increased to $85^0 C$ and 4g of activated carbon was added to each 100 ml of the oil sample, heated and stirred for 30 minutes. Then the mixture is separated using filter paper (Ismail *et al.,* 2022).

2.3.2 Transesterification
60g of the garlic oil has been measured in 250ml of conical flask and then heated and stirred to a temperature of 60 – 65℃ on a hot magnetic stirrer plate, 0.6g of NaOH was allowed to dissolve in 21ml of methanol and then allowed it to heat for 60 minutes with the stirrer on the hot magnetic plate. After 60 minutes of uniform stirring and heating on the hot magnetic plate maintaining a temperature of 65℃, then it was poured into the separating funnel through a glass funnel. The mixture is allowed to cool for about 40 minutes. Afterwards, it has been observed to separate into two liquid layers. The upper layer is the bio diesel and the lower layer is triglycrol fatty acid. Then the bio diesel has been separated from its byproduct (Ismail *et al.,* 2022).

2.3.3 Fourier Transform Infrared (FTIR) Spectroscopy Analysis
The FTIR analyses were done in order to analyze and show the presence of some key compound (methyl esters) in the samples. During the analysis, the sample in a form of thin film was placed between two potassium bromide discs made from single crystals, then a drop of the liquid is placed on one of the discs and the other is placed on top it which leads to the spreads of the sample into a thin film. The source which is located at the FTIR machine generates radiation which passes through the sample and interferometer and finally reaches the detector. Then the signal is amplified and then converted to digital signal by the amplifier and analog to digital converter respectively. Finally the signal is transferred to a computer in which Fourier transform is carried out (Ismail *et al.,* 2022).

2.4 Sample Measurement
The pour point, flash point and fire point of crude, purified and trans esterified garlic oil has been measured.

2.4.1 Measurement of Pour point
The pour point of crude garlic oils was measured using cylindrical test tube, thermometer, ice bath and retort stand. Crude garlic oil was poured into a cylindrical test tube to a 5ml mark level which is then clamped on a retort stand carrying the thermometer. This set up is then placed in a bath of ice and allowed to cool at a 3ºC. The lowest temperature at which the movement of the oil is observed within 5s is taken as pour point of the Crude garlic oil. The same procedure has been applied to the purified and trans esterified garlic oil (Ismail *et al.,* 2022).

2.4.2 Measurement of Flash point
Crude garlic oil was poured into a 100 ml conical flask to 10 ml mark level and then heated at a temperature between 14 to 17ºC/min on the hot magnetic plate until the temperature reaches 56ºC . The rate of change of temperature was then reduced to 5 to 6ºC/min and the test flame was applied to every 2ºC until the oil burn for at least 5s. The flash point was taken at the lowest temperature when an application of the flame test caused the vapor above the sample to ignite. The same procedure has been applied to the purified and trans esterified garlic oil (Ismail *et al.,* 2022).

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2.4.3 Measurement of Fire Point

Crude garlic oil was poured on to a 100ml conical flask to 10 ml mark level and then heated at a temperature between 14 to 17ºC/min on the hot magnetic plate until the temperature reaches 56ºC . The rate of change of temperature was then reduced to 5 to 6ºC/min and the test flame was applied to every 2ºC until the oil burn for at least 5s. The fire point was taken at the lowest temperature when an application of the flame test caused the vapor above the sample to burn for 5s. The same procedure has been applied to the purified and trans esterified garlic oil (Ismail *et al.,* 2022).

3. RESULTS AND DISCUSSIONS

3.1 FTIR Analysis

Figure 1 illustrates the FTIR spectrum plotted for transmittance (%) against the wave number (cm^{-1}) based on the amount of light absorbed by specific molecules present in the transesterified garlic oil.

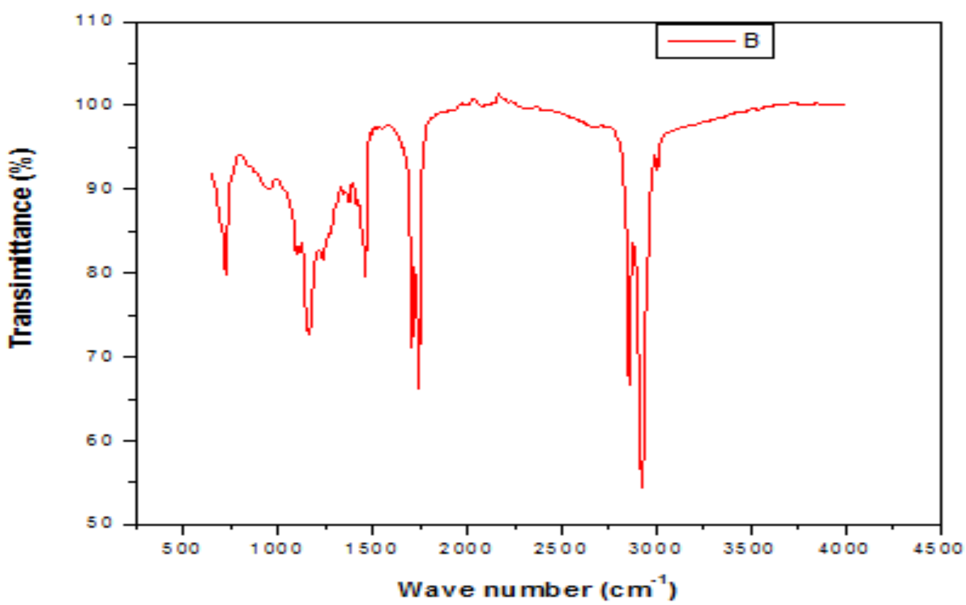

Figure 1: FTIR Spectra of Transesterified Garlic oil

From Figure 1, the bond with value 650 to 1400 cm^{-1} describes C-O bond, whereas 1500 to 1800 cm^{-1} describes C = O bond while 2700 to 3000 cm^{-1} described C-H stretching and finally from 3000 to 3700 cm^{-1} described OH bond. Here C – O and C = O signify the presence of ester or ether group in the sample as described by Ismail *et al.,* (2022). Therefore, from Figure 1 the ester peak was found to be at 1750 cm^{-1} which is similar to the results obtained by Muhammad *et al.,* (2023).

3.2 Pour Point, Flash Point and Fire Point of the Samples

The results of the pour, flash and fire point of the crude, purified and trans esterified garlic oil are presented on Table 1.

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Table 1: The Pour, Flash and Fire points of the crude, purified and transesterified garlic oil.

S/N	Garlic Oil	Pour Point (°)	Flash Point (°)	Fire Point (°)
1	Crude	8	120	130
2	Purified	6	145	160
3	Trans-esterified	4	160	185
4	Biodiesel Standard	-15 to 10	100 to 170	>130

It is trivial to see that from the above results (Table 1), that the pour point of the crude garlic oil corresponds to a temperature of 8°C which is within the range for a standard biodiesel but better still, a lower pour point will be more appreciated. For the purified and the trans-esterified garlic oil, their pour points correspond to temperatures of 6°C and 4°C respectively, which are better results than that of the crude oil. It has been reported that, the lower the pour point of a biodiesel, the better the biodiesel because such biodiesels with low pour point can remain active in diesel engines even in very cold weather. This is similar to the result obtained by Nura *et al.,* (2023).

Similarly, Though the biodiesel standard for the flash point ranges from 100°C to170°C, the diesel standard ranges from 60°C to 70°C, since the aim is to have oil that have diesel characteristic while still remains a biodiesel (from renewable resources), it is best for the oil to have a lower flash point (Note: minimum flash point for biodiesel standard is 100°C). In addition, it is practically okay for flash point of engine fuel to be relatively low. It can therefore be seen that the purified and the trans-esterified garlic oil flash points correspond to temperatures of 145°C and 160°C respectively, this shows an improvement compared to the crude garlic oil with flash point 120°C. This corresponds to the result of Raja *et al.,* (2011). A similar explanation holds for the fire point, It can also be observed that the fire point of the purified and the trans-esterified garlic oil correspond to temperatures of 160°C and 185°C respectively, this implies a better result compared to the crude garlic oil with fire point 130°C. Similar results were obtained by Nura et al. (2023).

4. Conclusions

In conclusion, biodiesel was produced via trans-esterification reaction and the purification technique. For the FTIR spectra, both results of the purified and the trans-esterified garlic oil are similar with some significant differences. The compounds present as previously shown in the explanation prove that the purified and trans-esterified garlic oil can be called methyl esters (biodiesel). Similarly, the results of the pour point of the purified and the trans-esterified garlic oil had a significant improvement as relate to the crude. The flash point and fire point of the purified and trans-esterified garlic oil are significantly better than the crude. Furthermore, by comparison with the international standard of biodiesels, the biodiesel samples (the purified and the trans-esterified garlic oil) were found to be in conformity.

References

Atadashi, I. M., Aroua, M. K. and Abdul Sziz, A. (2010). Biodiesel Separation and Purification: A Review. *Renewable Energy,* **36** (2), 437 - 443.

Ayoola A.A., (2015). Production and Life Cycle Assessment of Biodiesel from Three Waste Oils. Doctoral Dissertation, Covenant University Nigeria.

Barnwal, B. K., & Sharma, M. P. (2005). Prospects of Biodiesel Production from Vegetable Oils in India. *Renewable and Sustainable Energy Reviews*.

Bateni H., Saraeian A., Able C. (2017) A Comprehensive Review on Biodiesel Purification And Upgrading. *Biofuel Research Journal,* Pp. 668-690.

Bateni, H., Bateni, F., Karimi, K., (2016). Effects of Oil Extraction on Ethanol And Biogas Production From *Eruca Sativa* Seed Cake. *Waste Biomass Valorization*. Pp. 1-9.

Chao-Yi Wei, Tzou-Chi Huang, Zer-Ran Yu, Be-Jen Wang and Ho-Hsien Chen. (2014). Fractionation for Biodiesel Purification Using Supercritical Carbon Dioxide.*7*, 824-833; doi:10.3390/en7020824.

Indhumathi, P., PS, S. S., & Shoba, U. S. (2014). A Method for production and characterization of biodiesel from green micro algae. *International Journal of Bio-Science and Bio-Technology*, *6*(5), 111-122.

Ismail, U.I., Jamo, H.U., Usman, A., Magama, A.A., Baban, K.Y., Nura, I., Turaki, S., Musa, F.U. & Gwadabe, S.H., (2022). Influence of eggshell as heterogeneous catalyst in the production of biodiesel via transesterification of Jatropha oil. *Science World Journal, 17(*2), 191-195.

Karaosmanoglu, F. (1999). Vegetable oil fuels: a review. *Energy sources*, *21*(3), 221-231.

Knothe, G. (2010). Biodiesel and renewable diesel: A comparison. *Progress in Energy and Combustion Science,* Vol.36, No.3, Pp. 364-373.

Knothe, G., Dunn, R. O., & Bagby, M. O. (1997). Biodiesel: the use of vegetable oils and their derivatives as alternative diesel fuels. In *ACS symposium series.* Vol. 666, pp. 172-208.

Muhammad Z., Maina, I., Aliyu, A., Abubakar, D., Muhammad, S., Dalhatu, S., & Ismail, U. (2023). Synthesis of Biodiesel From Clove Oil Via Transesterification. *Bima Journal of Science and Technology.*7(21), 160-167.

Murugesan, A., Umarani, C., Subramanian, R. & Nedunchezhian, N. (2009). Bio-diesel as an alternative fuel for diesel engines-A review, *Renewable & Sustainable Energy Reviews*, Vol. 13, No. 3, pp. 653-62.

Nigam, P.S. & Singh, A. (2011). Production of liquid biofuels from renewable resources. *Progress in Energy and Combustion Science,* Vol.37, No.1, (2), pp. 52-68.

Nura, I., Jamo, H.U., Getso, I.Y., Tolufase, E., Belo, O.M., Ismail, U.I., Musa, F.U. & Yusuf, A., (2023). The effect of addition of fly ash on physical properties of transesterified calabash oil as source of biodiesel. *Science World Journal*, 18(1), 55-59.

Paul Vossen, (2007) Olive Oil: History, Production, and Characteristics of the World's Classic Oils; Hort Science: vol. 42 no. 5 1093-1100.

Peterson, C. L. (1986). Vegetable oil as a diesel fuel: status and research priorities. *Transactions of the ASAE*, 29(5), 1413-1422.

Raja, S. A., Robinson smart, D.S. & C.Lindon Robert Lee., (2011). Biodiesel production from jatropha oil and its characterization. *Res J Chem Sci*, 1, .81-87.

Samadi, S., Karimi, K., Behnam, S., (2017). Simultaneous biosorption and bioethanol production from lead-contaminated media by mucor indicus. *Biofuel Res. J.* 4(1), 545-550.

Satyal, P., Craft, J. D., Dosoky, N. S., & Setzer, W. N. (2017). The chemical compositions of the volatile oils of garlic (Allium sativum) and wild garlic (Allium vineale). *Foods,* 6(8), 63.

Sundar Raj, C., & Sendilvelan, S. (2010). Effect of oxygenated hydrocarbon additives on exhaust emission of a diesel engine. *International Journal of Automotive and Mechanical Engineering*, 2, 144-156.

Tremblay, A.Y., Cao, P., Dubé, M.A., (2008). Biodiesel production using ultra-low catalyst concentrations. *Energy Fuels*. 22(4), 2748-2755.

Zach Waickman, (2017). Biodiesel Lab Manager; Teacher Manual with Student Documents, Loyola University of Chicago Institute of Environmental Sustainability Biodiesel Program.

Zuhal, O., & Kemal, O. H. (2004). Turkish sugar production potential and use of waste of sugar beet as energy source. *International Journal of Green Energy*, 1, 381-392.